Colorado Water Quality Control Division

WATER QUALITY

PERMITS

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Guidelines for the Determination of Agronomic Rate for Application of Reclaimed Water Under Colorado Regulation No. 84

Purpose: To provide site-specific guidance to Colorado Water Quality Control Division staff (herein referred to as the "Division") with implementation of the Colorado Water Quality Control Commission *Reclaimed Water Control Regulation* (Regulation No. 84). These guidelines are specifically intended to address application of reclaimed water at agronomic rates, as required in the "Administration Section of Regulation 84.6(A)(3), that states:

> "An analysis that demonstrates that reclaimed water used for landscape irrigation will be applied at or below the agronomic rates. Landscape irrigation uses may also be subject to waste load allocations or limits as contained in a Total Maximum Daily Load (TMDL) or control regulation governing the watershed within which the irrigation occurs."

These guidelines define the procedure for evaluating compliance with the agronomic rate for nitrogen when reclaimed water is applied to turf grass (since most reclaimed water is currently applied to turf grass) and provide references which establish that an agronomic rate calculation for phosphorus is not needed except as it may be required where reclaimed water is applied to land included in and regulated by a watershed control regulation. For irrigated plants other than turf grass, Treaters must demonstrate (via supporting data and calculations) compliance with the nitrogen agronomic rate criteria for that specific plant species. In all cases, it is the responsibility of Treaters to demonstrate to the Division that reclaimed water is being applied at agronomic rates.

Procedure: Based on recommendations from the Colorado State University Cooperative Extension, the Division shall use the following values as acceptable agronomic rates for turf grass for a calendar year:

Nitrogen	174 pounds per acre
Phosphorus*	No concentration or mass limit

Specific procedures for calculating the annual amount of reclaimed water to apply to meet the nitrogen requirement are outlined in the following paragraphs.

Agronomic Rate of Reclaimed Water: Nitrogen-Based

In order to determine the amount of reclaimed water to apply to meet the nitrogen needs of turf grass, an annual average Total Inorganic Nitrogen (TIN) value needs to be determined using the following process. For each month of reclaimed water delivery to customers, the Treater shall average all laboratory results for (TIN) concentration of the water taken at the compliance point (specified in the Treaters' Notice of Authorization). This calculation shall determine a monthly average for TIN. These monthly averages shall be summed, then divided by the number of months of water delivery to customers to determine an annual average for the calendar year.

The Treater shall insert the annual average TIN value into the following equation and, using the total volume of reclaimed water to be applied by all of the Treaters' irrigation customers and the total number of acres to be irrigated by these customers (regardless of whether such irrigation is governed by this regulation), perform the calculation. No flow-weighting shall be applied to any of the averaging.

$$\frac{\text{(Total Annual Volume of Reclaimed Water Applied in Million Gallons)} \times \text{(Average Annual TIN in mg/L)} \times 8.34}{\text{(Total Area Irrigated with Reclaimed Water in acres)}}$$

Compare the result of this equation to 174 lbs/ac/yr provided that the area reclaimed water is applied to is $\geq$ 90% turf grass. If the calculated result is less than or equal to 174 lbs/ac/yr, no further action is required. If the result is greater than 174 lb/ac/yr, where the Treater believes there are different plant/soil conditions, the Treater shall prove, using alternate means, compliance with the Regulation No. 84 agronomic rate requirement to the Division or provide treatment that decreases TIN in the reclaimed water. Where the area reclaimed water is applied to is less than 90% turf grass, the Treater shall prove, using alternate means, compliance with the Regulation No. 84 agronomic rate requirement to the Division and/or provide treatment that decreases TIN in the reclaimed water.

Agronomic Rate of Reclaimed Water: Phosphorus-Based

Under most conditions, phosphorus is quickly sequestered in soil types typically encountered in areas to be irrigated with reclaimed water and is not able to migrate beyond the first few inches of topsoil as water passes through it. The mechanisms of phosphorus adsorption in soil are discussed in the references listed in the Background Section of this guidance document (see below). This may not apply where underlying soils are sandy.

Since phosphorus is generally immobile in soil types typically encountered in areas to be irrigated with reclaimed water, it is unlikely this application will affect groundwater phosphorus concentrations. Therefore, determination of an agronomic rate for phosphorus is unnecessary, provided that reclaimed water is not applied to land governed by a watershed control regulation[1]. If reclaimed water is to be applied within an area that is under the jurisdiction of a watershed control regulation, the Treater shall demonstrate compliance with the applicable control regulation to the satisfaction of the Division, or provide treatment that decreases phosphorus concentrations in the reclaimed water.

Background: These guidelines were developed by a subcommittee of the Rocky Mountain Section American Water Works Association / Rocky Mountain Water Environment Association Joint Water Reuse Committee (RMSAWWA/RMWEA Joint Water Reuse Committee), a group representing various stakeholders of reclaimed water including the Division. The intent of the guidelines is to provide a tool that will help ensure compliance with the provisions of Regulation No. 84 for nitrogen and phosphorus-based nutrient compounds. As discussed in Section 84.21.B, *Regulatory System Overview*, "The Commission does not intend that these regulations be used to limit flexibility to apply additional nutrients to landscaping being irrigated with reclaimed domestic wastewater." Therefore, the criteria apply only to nitrogen and phosphorus loadings applied to turf grass via reclaimed water.

During formulation of these guidelines, three different nitrogen species were considered for monitoring and incorporation into the agronomic rate equation: 1) Total Nitrogen, 2) TIN, and 3) TIN plus an "organic factor." The third option was considered upon a suggestion from a committee member who opined that since the organic fraction of nitrogen is likely to be quite stable and can be difficult/expensive to measure (depending upon the size and budget of a particular Treater), a baseline number representing the organic fraction could be added to TIN to obtain an estimated value for Total Nitrogen. The subcommittee evaluated data from Ohio State University which supported the use of TIN[1]

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[1] Although an agronomic rate for phosphorus is not included in Regulation No. 84 for application of reclaimed water to turf grass, the Division may impose an agronomic rate or other requirements governing phosphorus loading for reclaimed water applied to land governed by a watershed control regulation.

This data shows that the organic fraction of nitrogen in wastewater is not readily available for plant uptake and becomes part of the soil mass. Similar information from wastewater treatment manuals and other states suggest that the organic fraction of nitrogen is ring- bound and is not available for plant uptake[2]. Samples from several subcommittee members' reclaimed water utilities showed that the organic fraction of total nitrogen is typically 1-2 mg/L and is, therefore, not a significant portion of total nitrogen. Based upon this data and discussion amongst subcommittee members, TIN was selected as the parameter to be used to determine compliance with nitrogen agronomic rate.

The behavior of phosphorus compounds in soil is complex. However, after reviewing the publications of many authorities on the fate and transport of phosphorus in soil, the subcommittee concluded that in application areas that are not governed by a watershed control regulation, reclaimed water should not be regulated by an agronomic rate factor for phosphorus. When phosphates come into contact with soil, a series of reactions occur which make them less soluble and less available[3]. The specific reaction rates and products are functions of site-specific soil parameters such as pH, moisture content, temperature, and levels of other minerals present, but research has shown that practically all phosphorus from fertilizer (including manure) is converted to water insoluble phosphorus in soil within a few hours after application. The phosphate ions $H_2PO_4^-$ and HPO_4^{-2} react quickly with iron, aluminum, manganese, and calcium to form insoluble precipitates. The result is that "phosphate ions do not leach, as do nitrate ions, even in sandy soils"[4]. The University of Wisconsin article goes on to state:

> "Studies of highly fertilized, intensively farmed land indicate that the annual loss of phosphorus in drainage water seldom exceeds 0.1 lb/a. The plow layer of the soil usually retains almost all (98-99%) of the applied phosphorus. This means that very little phosphorus moves into or through the subsoil."

Soil and Applied Phosphorus further opines:

> "Despite claims to the contrary, research has shown that liquid phosphate does not improve fertilizer phosphorus availability or recovery. It is the soil interactions that control phosphorus uptake, not the physical form of the fertilizer applied."

University of Minnesota Publication FO-06795-GO, *The Nature of Phosphorus in Soils*, states that most soils have the capacity to retain phosphorus, even large additions associated with fertilization. The article also states that phosphorus problems in surface waters are primarily associated with sediment runoff where phosphorus is bound to the soil particles and can remobilize under certain conditions in the water body.

See also the Livestock and Poultry Environmental Stewardship (LPES) Curriculum lesson 34-3 *Phosphorus in Soil* and the University of Wisconsin-Extension document A2520 Understanding Plant Nutrients – Soil and Applied Phosphorus (E.E. Schulte and K.A. Kelling).

References

[1] Mancl, Karen and Don Rector. "Reuse of Reclaimed Wastewater Through Irrigation". Ohio State University Extension - Bulletin 860 Reuse of Reclaimed Wastewater Through Irrigation for Ohio Communities. 1997. Part 2, Design, Land requirements, Step 6. Ohio State University. January 22, 2007. < http://ohioline.osu.edu/b860/b860_13.html >.

[2] "Biological and Chemical Systems for Nutrient Removal: Special Publication". Water Environment Federation, (1998)
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Winstanley, Derek. "Conceptual Model of Nitrogen Cycling". Nitrogen Cycles Project Illinois Council on Food and Agricultural Research (C-FAR) and the Illinois State Water Survey (ISWS). January 22, 2007. http://www.sws.uiuc.edu/nitro/.

[3] Busman, Lowel, et al. "The Nature of Phosphorus in Soils". University of Minnesota Publication FO-06795-GO. 2002. Phosphorus in the Agricultural Environment. University of Minnesota Extention Service. January 22, 2007. < http://www.extension.umn.edu/distribution/cropsystems/DC6795.html >

[4] Shulte, E.E. and Kelling, K.A. "Soil and Applied Phosphorus". University of Wisconsin Publication A2520 1996. Understanding Plant Nutrients. University of Wisconsin-Extension, Cooperative Extension. January 22, 2007. < http://learningstore.uwex.edu/pdf%5CA2520.pdf >